BUILDING ENERGY EFFICIENCY MEASURE PROPOSAL TO THE

CALIFORNIA ENERGY COMMISSION

FOR THE 2022 UPDATE TO THE

CALIFORNIA ENERGY CODE, TITLE 24, PART 6

BUILDING ENERGY EFFICIENCY STANDARDS

DEMAND MANAGEMENT – CONTROLLED RECEPTACLES

Nonresidential Demand Management

Prepared by: California Energy Alliance *June* 2020

TABLE OF CONTENTS

List of Tables and Figures

Document Information

Category: Codes and Standards

Keywords: Energy Code, Statewide Codes and Standards, Title 24, 2023, efficiency, controlled receptacles, demand management, automated demand response, lighting.

EXECUTIVE SUMMARY

Introduction

This proposal presents recommendations to support California Energy Commission's (Energy Commission) efforts to update the Title 24 Standards to include or upgrade requirements for various technologies in California's Building Energy Efficiency Standards. The California Energy Alliance (CEA) sponsored this effort. The goal of this proposal is to create new measures that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the Energy Commission effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

Scope of Code Change Proposal

Demand Management – Controlled Receptacles will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

Standards Requirements (see note below)	Compliance Option	Appendix	Modeling Algorithms	Simulation Engine	Forms
M	Ps, Pm	NA 7.6.3	YES	YES	NRCC-ELC-E NRCI-ELC-E NRCA-LTI-A

Note: An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

- Mandatory – Section 110.12(e) Demand Responsive 120-V Controlled Receptacles (new)
- Mandatory – Section 130.4(a)8. Lighting Control Acceptance and Installation Certificate Requirements
- Mandatory – Section 130.5(e) Demand Responsive controls and equipment
- Mandatory – Section 141.2(P)iv – Electrical Power Distribution Systems

Measure Description

The proposed measure addresses automated demand control of controlled receptacles for newly constructed buildings, building additions and building alterations. For all building areas that are required to install controlled receptacles and demand responsive lighting controls, those building areas will also be required to make the controlled receptacles capable of responding to a demand response signal in accordance with Section 110.12 Demand

Management. For newly constructed buildings, additions and alterations not required to install both of these items, the building would be exempt from the proposed requirements.

The proposed measure is intended to reduce the energy demand and consumption of miscellaneous electric loads (MELS) connected to controlled receptacles, also referred to as plug loads. According to the U.S Department of Energy, these loads account for 82 percent of all miscellaneous energy loads in buildings. MELS represent the electricity used by devices and appliances outside of a building's core functions of heating, ventilation, air conditioning, lighting, water heating and refrigeration (DOE, 2016). Examples of MELS devices include computers, monitors, coffee makers, phone charges, and copy machines. Recent studies have demonstrated that approximately 30 percent of a building's total electricity use (NEMA, Meier et. al., PNNL) is attributed to MELS, far surpassing that of lighting systems given the near-recent commercial transition to low energy LED lighting systems.

Because the cost-effectiveness and energy savings associated with demand responsive lighting controls have already been established for a range of non-residential buildings in California, and for these buildings, the addition of control nodes for receptacles represents a small additional cost, it only makes sense that receptacles be added to demand management requirements. This will provide building owners and operators with an additional option for reducing energy and demand costs given the forthcoming transition to time-of-use and dynamic pricing utility tariffs.

Market Analysis and Regulatory Impact Assessment

Looking at existing industry capabilities, many control systems available in the market today can provide significantly more benefits for electric grid stabilization and the reduction of energy consumption beyond pure energy (kWh) management. With minimal disruption to business operations or additional cost to the building owner, controlled receptacles could reduce peak energy demand (kW) and provide more significant system synergies with how and when energy is consumed.

This proposal is cost effective over the period of analysis. Overall, this proposal increases the wealth of the State of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure. As a result this leaves more money available for discretionary and investment purposes.

Statewide Energy Impacts

The proposed measure will save 0.85 GWh and 34.6 MW of peak demand over the first twelve months of implementation. Table 2 shows all expected first-year savings expected from implementation of the Demand Management Updates – Controlled Receptacles measure. Section 4.2 discusses the methodology and Section 4.3 shows the results for the per unit energy impact analysis.

Table 2: Statewide Estimated First Year Energy Savings

	First Year Statewide Savings			First Year Statewide TDV Savings	
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings (Million kBTU)	TDV Natural Gas Savings (Million kBTU)
Demand Responsive, Controlled Receptacles	0.85	34.6	N/A	7.92	N/A
TOTAL	0.85	34.6	N/A	7.92	N/A

Compliance and Enforcement

The proposed compliance and enforcement process to ensure the success of the measure is described in Section 2.5. The impacts the proposed measure will have on various market actors is described in Section 2.5. The key changes related to compliance and enforcement are summarized below:

- Addition of mandatory requirements for automated demand response controls for controlled receptacles.
- New acceptance test for controlled receptacles to verify the proposed measures when conducting a demand responsive lighting controls acceptance test.

Cost-effectiveness

The TDV Energy Costs Savings are the present valued energy cost savings over the 15-year period of analysis using Energy Commission's TDV methodology. The Total Incremental Cost represents the incremental initial construction and maintenance costs of the proposed measure relative to existing conditions (current minimally compliant construction practice when there are existing Title 24 Standards). Costs incurred in the future (such as periodic maintenance costs or replacement costs) are discounted by a three percent real discount rate, per Energy Commission's LCC Methodology. The Benefit to Cost (B/C) Ratio is the incremental TDV Energy Costs Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the discounted energy cost savings and the measure is deemed to be cost effective. For a detailed description of the Cost-effectiveness Methodology and Results, see Section 5.1 and 5.2 of this report.

Because the measure is not significantly impacted by climate, this analysis uses statewide, average TDV factors. The proposed measure is cost-effective for all building types evaluated with one adjustment made to two building types. For certain buildings with very small areas required to have controlled receptacles, such as office areas in quick service restaurants, the additional of demand response hardware does not pay for itself over the 15-year period of analysis. However, given the change proposed by the IOU CASE team in their Nonresidential Grid Integration measure, of a 4000 W minimum threshold, among other exemptions for inclusion of demand responsive lighting controls, small areas such as those described would be automatically exempt from the proposed demand responsive controlled receptacle requirements [CASE, 2020]. Thus, for simplicity, the CEA calculated the Benefit-to-Cost ratio for these two buildings, quick service restaurants and warehouses, assuming applicable building areas of 1,900 sf, which is the approximate area serviced by a fully loaded 20-amp circuit. Under these conditions and all those with larger regulated areas, the proposed measure is cost-effective with Benefit-to-Cost Ratios ranging from 1.2 to 3.65. In addition, no additional exemptions are required to address these design scenarios as small areas are effectively exempted because the area will not be required to include demand responsive lighting controls. A summary of these results in shown in Table 3.

Table 3: Cost-effectiveness Summary per Unit

Building Type	Benefits TDV Energy Cost Savings + Other PV Savings[1] (2023 PV $)	Costs Total Incremental Present Valued (PV) Costs[2] (2023 PV $)	Benefit-to-Cost Ratio
Small Office	$0.18	$0.10	1.8
Medium Office	$0.18	$0.08	2.3
Large Office	$0.18	$0.07	2.6
Strip Mall	$0.28	$0.13	2.2
Stand-alone Retail	$0.28	$0.15	1.9
Large Retail	$0.28	$0.08	3.5
Mixed Use Retail	$0.28	$0.09	3.1
Primary School	$0.18	$0.07	2.6
Secondary School	$0.18	$0.08	2.3
Warehouse	$0.18	$0.15	1.2
Quick Service Restaurant	$0.28	$0.15	1.9
Small Hotel	$0.23	$0.13	1.8

Greenhouse Gas and Water Related Impacts

The proposed measure will result in a significant amount of avoided greenhouse gases. No water impacts are expected. For more a detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measure, please refer to Section 6.2 through 6.5.

Greenhouse Gas Impacts

The monetary value of avoided greenhouse gas (GHG) emissions is included in TDV cost factors (TDV $) and is thus included in the Cost-effectiveness Analysis prepared for this report. CEA utilized disaggregated values of avoided costs attributed to avoided GHG emissions in order to calculate their monetary value separately. Table 4 presents the estimated avoided GHG emission costs of the proposed code change for the first year the standards are in effect.

Assumptions used in developing the GHG savings are provided in Section 6.2 and Appendix C of this report.

Table 4: Estimated Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions ($MTCO_2e$/yr)	**Monetary Value of Avoided GHG Emissions ($2023)**
Demand Responsive Controlled Receptacles	192.6	pending
TOTAL	192.6	pending

Water Use and Water Quality Impacts

The proposed measure is not expected to have any impacts on water use or water quality, excluding impacts that occur at power plants.

Acceptance Testing

New acceptance testing requirements for controlled receptacles connected to demand responsive control systems will be required. This test will be integrated as part of the lighting controls acceptance test for demand responsive controls and reported on that form. Because demand responsive controlled receptacles will only be required if the area they serve also requires demand responsive lighting controls, the two acceptance tests can be combined.

1. INTRODUCTION

The California Energy Alliance (CEA) sponsored this effort. The goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficiency design practices and technologies.

The overall goal of this Report is to propose a code change proposal for additional Demand Management Updates to be applied in conjunction with the recommendations provided in the Nonresidential Grid Integration report prepared by the California Statewide Codes and Standards Enhancement (CASE) Program. The report contains pertinent information that justifies the code change.

Section 2 of this Report provides a description of the measure, how the measure came about, and how the measure helps achieve the state's zero net energy (ZNE) goals. This section presents how the proposed code change would be enforced and the expected compliance rates.

Section 3 presents the market analysis, including a review of the current market structure, a discussion of product availability, and the anticipated useful life and persistence of the proposed measure. This section offers an overview of how the proposed standard will impact various stakeholders including builders, building designers, building occupants, equipment retailers (including manufacturers and distributors), energy consultants, and building inspectors. Finally, this section presents estimates of how the proposed change will impact statewide employment.

Section 4 describes the key assumptions used in the energy savings analysis, the energy savings methodology and provides the per-unit energy impacts and energy savings results. These results are based on the methodology and assumptions contained in the Nonresidential Grid Integration CASE report and are intended to supplement those recommendations and savings.

Results from the energy, demand, costs, and environmental impacts analysis are presented in Sections 5 and 6. The authors calculated energy, demand, and environmental impacts using three metrics: (1) per square foot, (2) statewide impacts during the first year buildings complying with the 2022 Title 24 Standards are in operation, and (3) the cumulative statewide impacts for all buildings impacted during the 15-year period of analysis. Time Dependent Valuation (TDV) energy impacts, which accounts for the higher value of peak savings, are presented per square foot, first year statewide and cumulative statewide. The incremental costs, relative to existing conditions are presented as are present value of the TDV energy cost savings and the overall cost impacts over the 15-year period of analysis.

Section 7 of the report concludes with specific recommendations for language for the Standards, Appendices, Alternate Calculation Manual (ACM) Reference Manual and Compliance Forms.

2. MEASURE DESCRIPTION

2.1 Measure Overview

The proposed measure will require that building spaces required to install controlled receptacles and demand responsive lighting controls, will also be required to make the controlled receptacles capable of automatically responding to a demand response signal. Buildings will benefit from demand responsive, controlled receptacles.

The California Energy Alliance performed a market analysis with the goals of identifying current technologies, product availability, and market trends related to automatic demand responsive (ADR) electrical receptacles for nonresidential buildings. It considered how the proposed standard might impact and align with measures included in the 2022 Nonresidential Grid Integration CASE Report prepared by the California Statewide Energy Codes and Standards Enhancement (CASE) Program, as well as other standards currently required in Title 24, in order to create synergies that maximize combined derived benefits.

Looking at existing industry capabilities, many control systems available in the market today can provide significantly more benefits for electric grid stabilization and the reduction of energy consumption beyond pure energy (kWh) management. With minimal disruption to business operations or additional cost to the building owner, use of controlled receptacles could reduce peak energy demand (kW) and provide more significant system synergies with how and when energy is consumed. The pieces of the system infrastructure required to deliver these benefits are already in place, which make this recommendation technically viable and cost-effective.

- Title 24 Section 130.5 – Electrical Power Distribution Systems, subsection (d) Circuit Controls for 120-Volt Receptacles and Controlled Receptacles mandates the use of controlled receptacles when the space is unoccupied, either at the receptacle or circuit level.
- Title 24 Section 110.12 – Mandatory Requirements for Demand Management describes when demand responsive lighting controls must be used.

Adding a mandatory requirement that controlled receptacles be capable of automated demand response whenever demand responsive lighting controls are required in a space would yield additional energy and peak demand savings, and additional synergies beyond either system's individual operation.

The benefits of integrating controlled receptacles with ADR demand management would provide a more stabilized electrical grid and peak load reduction benefits to all 16 climate zones ubiquitously.

Since customers of every type, size, and market sector can participate in DR programs in California, enabling demand responsive receptacles can further encourage more cost-effective and higher levels of automated grid transactions in buildings.

2.2 Measure History

The proposed measure was developed in coordination with the IOU Codes & Standards CASE team, which submitted a 2022 code change proposal focused on nonresidential grid integration [CASE, 2020]. This measure seeks to expand the deployment of demand responsive building systems to include miscellaneous electric loads connected to controlled receptacles. MELS account for 20-30 percent of a nonresidential building's electricity use. They present a greater opportunity for demand reduction and flexibility than most modern lighting systems, which are currently required to be capable of automatically responding to demand response signals. California policies call for increased grid flexibility, decarbonization and significant reductions in building electricity use. This can only be accomplished by addressing miscellaneous electric loads, as well as other unregulated loads in nonresidential buildings. The California Energy Alliance, in collaboration with its member partners, developed this code change proposal to support a practical next step in California's transition to a reduced carbon economy.

2.3 Summary of Proposed Changes to Code Documents

The sections below provide a summary of how each Title 24 document will be modified by the proposed change. See report Section 7, Proposed Revisions to Code Language, for detailed proposed revisions to code language.

2.3.1 Standards Change Summary

This proposal would modify the following sections of the Building Energy Efficiency standards as shown below. See *Section 7.1* of this report for the detailed proposed revisions to the standards language.

Section 110.12(e) Demand Responsive Controlled Receptacles

This measure would add a new requirement that controlled receptacles installed in buildings spaces that also require demand responsive lighting controls be capable of automatically turning off connected devices in response to a demand response signal.

Section 130.4(a)8. Lighting Control Acceptance Requirements

This measure modifies the lighting controls acceptance for demand responsive controls to include checks and certifications to ensure lighting controls providing demand response to controlled receptacles comply with Section 110.12(e), 130.5(d), and Nonresidential Appendix 7.6.3.

Section 130.5(d) Circuit Controls for 120-Volt Receptacles and Controlled Receptacles

This measure would add a new item to the section that requires controlled receptacles to be connected to demand responsive controls that are capable of automatically turning off connected devices when they are located in building spaces that also require demand responsive lighting controls.

Section 141.2(P) Electrical Power Distribution Systems

This measures would require qualifying alterations to comply with the new demand response requirements contained in Section 110.12(e).

2.3.2 Reference Appendices Change Summary

This proposal would modify the following sections of the Standards Appendices as shown below. See Section 7.2 Reference Appendices of this report for the detailed proposed revisions to the text of the reference appendices.

Reference Appendix 7.6.3 Demand Responsive Lighting Controls

This measure would modify acceptance tests for demand responsive lighting controls to include a check that certifies the controls are connected to controlled receptacles, when required, and are capable of automatically turning off miscellaneous electrical loads connected to the controlled receptacles in response to a demand response signal.

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

The proposed code change will not modify the ACM Reference Manual.

2.3.4 Compliance Manual Change Summary

The proposed code change will modify the following section of the Title 24 Compliance Manual: Chapter 8 – Electrical Power Distribution including changes to the Acceptance Testing chapter of the NR manual. Some updates to Chapter 5 – Indoor Lighting will be required to reference the new requirements pertaining to controlled receptacles.

2.3.5 Compliance Forms Change Summary

The proposed code change will modify the following compliance forms listed below. Examples of the revised forms are presented in *Section 7.5 Compliance Forms*.

- **Form 1 – NRCC-ELC-E Certificate of Compliance Electrical Power Distribution Systems**: The form would be modified to include a list of areas that require controlled receptacles enabled with demand responsive controls. The form would include an area to note if the receptacles also required an acceptance test to verify compliance.
- **Form 2 – NRCI-ELC-E Certificate of Installation Electrical Power Distribution Systems**: This form would be modified to include confirmation that controlled receptacles requiring connection to demand responsive controls are installed as designed and specified.
- **Form 3 – NRCA-LTI-A Certificate of Acceptance Indoor Lighting Controls**: This form would be modified to include acceptance test requirements and procedures for verifying that controlled receptacles connected to lighting control systems are capable of automatically turning off connected loads in response to a demand response signal.

2.4 Regulatory Context

2.4.1 Existing Standards

Currently, controlled receptacles are required for new construction and alterations completed under 2019 ASHRAE 90.1 Energy Standards for Buildings except Low-Rise Residential Buildings. Unlike the Energy Standards, ASHRAE Standards require use of controlled receptacles in classrooms and on a larger portion of alterations. 2019 ASHRAE 90.1 is more stringent than current Title 24, Part 6 requirements pertaining to use of controlled receptacles. However, the ASHRAE 2019 standard does not require demand responsive controlled receptacles. [ASHRAE, 2019]

2.4.2 Relationship to Other Title 24 Requirements

The proposed measure is intended to supplement the measures proposed by the California IOU Codes & Standards team under their CASE proposal for Nonresidential Grid Integration. Additionally, the proposed measure relies on installation of demand responsive lighting controls that comply with Section 110.12 and controlled receptacles that comply with Section 130.5(d).

2.4.3 Relationship to Federal Laws

The proposed measure is not impacted by or in contradiction to any federal laws or statutes.

2.5 Compliance and Enforcement

The compliance process would include new responsibilities for the electrical engineer, installation team, acceptance test technicians (ATTs) and inspectors to ensure demand responsive, controlled receptacles are included and installed as required by the proposed measure. However, the process is essentially the same as that required currently for controlled receptacles and demand responsive lighting systems. Little to zero additional complexity is anticipated relative to the design and construction processes for a new building, building addition, or regulated alteration.

There is currently no compliance verification, such as a non-residential acceptance test, in place for controlled receptacles; however, the CEA recommends such a test be developed. Interviews and conversations with multiple commercial builders and code professionals indicates that code professionals already expect controlled receptacles to be verified as part of occupancy sensor acceptance tests for indoor lighting. The additional effort to verify occupancy control and demand response capabilities is estimated at 1 hour per control zone. Recommendations for a controlled receptacle acceptance test will be included in the final version of this proposal.

Compliance Process

- **Design Phase:** During the design phase, the electrical engineer is responsible for ensuring controlled receptacles are incorporated into the building design, as required. The electrical engineer would also be responsible for ensuring that controlled receptacles include demand responsive capabilities when the lighting system is also required to include demand responsive lighting controls. The design documents applicable to demand responsive lighting controls and controlled receptacles are NRCC-LTI-E Indoor Lighting Certificate of Compliance and NRCC-ELC-01-E Certificate of Compliance for Electrical Power Distribution. This form will require modification to accommodate information on demand responsive controls for controlled receptacles.
- **Permit Application Phase:** Plans examiners review design documents and confirm that the design complies with the controlled receptacle and associated demand response controls requirements.
- **Construction Phase:** The controlled receptacles and demand responsive controls are installed and commissioned during the construction phase. The details for controlled receptacles are reported on NRCI-ELC-E Certificate of Installation for Electrical Power Distribution. This form will require modification to accommodate information on demand responsive controls for controlled receptacles. Additionally, the controls must be configured so they are ready for the acceptance test for controlled receptacles (forthcoming in final proposal). The ATT completes the applicable acceptance test form, indicating if the system

has passed or failed the test. If necessary, the installation team completes changes to the system allowing it to comply with AT requirements and the ATT rechecks the system. Modifications to the existing indoor lighting controls acceptance test form will be required to accommodate acceptance tests for demand responsive controlled receptacles.
- **Inspection Phase**: The building inspector confirms that all necessary acceptance tests were completed and verifies that controlled receptacles are installed per the plans and compliance forms.

3. Market Analysis

The authors performed a market analysis with the goals of identifying current technology, product availability, and market trends associated with the use and potential of automated, demand responsive controlled receptacles. The authors considered how the proposed standard may impact the market in general and individual market players. The authors gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders, Energy Commission, and a wide range of industry players who were invited to participate in stakeholder meetings held in 2019 and 2020. Because the proposed measure is intended to supplement the 2022 CASE report on Nonresidential Grid Integration, much of the market analysis it contains is also directly applicable to this proposal. For brevity, that information is not repeated in this report. In addition to the information contained below, readers are encouraged to review the Grid Integration report for more information on market structures and impacts of demand responsive control technologies [CASE, 2020].

3.1 Technical Feasibility, Market Availability and Current Practices

Existing industry capabilities are ubiquitous to successfully implement this proposed measure. When a demand responsive lighting control system and controlled receptacles are required per the 2019 Energy Standards, there are only very small additional costs to enable controlled receptacles with demand response capabilities. In particular, when lighting control systems are used, as opposed to piecemeal approaches, adding controlled receptacles is very simple and devices are readily available to achieve the proposed measure. Table 5 includes a short list of controls manufacturers offering systems capable of equipping and incorporating controlled receptacles with demand response capabilities.

Table 5: Manufactures and Products: Controlled Receptacles with Demand Response Capabilities

Manufacturer	Products/System	Remarks
Autani	EnergyCenter	Controlled receptacles are simply added to a demand response control zone via existing Autani EnergyCenter software.
Eaton / Cooper	WaveLinx / Greengate	Controlled receptacles are simply added to a demand response control zone via existing WaveLinx software.
Honeywell	LCBS Connect	Utilizes Internet of Things / Cloud base technology supporting multiple platforms such as Zigbee, OpenADR, WiFi, etc. that can send a signal to enable/disable controlled receptacles from the HVAC control system.
Legrand / WattStopper	DLM / Legrand	Legrand/WS have several solutions to accomplish the management and control of electrical systems, and can be controlled from WS DLM network lighting controls VEN or to an HVAC control system VEN.
Lutron	Vive	Vive wireless hub utilized to control the lighting system is able to control and manage Vive controlled receptacles.
RAB Lighting	LightCloud	Controlled receptacles are simply added to a demand response control zone via existing LightCloud software.
Leviton	GreenMax	Controlled receptacles are simply added to a demand response control zone via existing software.

*All manufacturers utilize a controller and gateway to communicate to local devices and controlled receptacles and/or circuits of controlled receptacles and are compatible with Open ADR 2.0b.

In new construction, the probability that projects incorporate piecemeal approaches to achieve demand responsive lighting control is very low. Networked lighting control system manufactures offer controllable electrical receptacles with demand response features and receptacles are simply added to the demand response control zone during system commissioning. This process is generally completed through the front-end software interface, and no software and little additional hardware will be required unless the additional device count exceeds the manufacturer's design limits for their product line. The process for adding controlled receptacles to a demand response control zone can occur during system commissioning, factory startup, or added at any point in time after installation.

Existing industry product lines and systems from multiple manufacturers can expand the capabilities of controlled receptacles to include demand management with a small amount of additional cost to the customer/building owner.

Speaking directly with lighting and building controls manufacturers Acuity Brands, Autani, Eaton/Cooper, Legrand/WattStopper, Lutron, and RAB Lighting, the manufacturers all stated that the incremental construction cost and post-adoption additional construction costs are minimal. No new software and little additional hardware is required to add plug load control to networked controls as long as their controlled hardware was already being used to control the lighting. The front-end equipment to meet Energy Standards demand responsive lighting requirements and the proposed controlled receptacle requirements are already in place. Enabling demand responsive, controlled receptacles is achieved by adding load controllers to the controlled receptacle circuits. Then, these circuits are added to a demand response zone in the startup process via system software.

Legrand is one of many companies that offer multiple types of controllable receptacle solutions capable of providing demand management solutions for retrofits, major renovation, and new construction. Wired and wireless networked solutions are available to meet the proposed measure at the room level and/or at a circuit level.

Honeywell also offered insight that any control system capable of IoT communication is capable of managing controlled electrical receptacles, and with a multitude of manufacturers creating and managing IoT devices, implementing demand management controls would be a simple process. IoT ready solutions are the most economical and cost-competitive systems in the market and provide an agnostic approach to making the components controllable with non-proprietary systems. Moreover, system aggregators specializing in demand management can integrate and manage these devices across multiple products with their respective control systems.

3.2 Market Impacts and Economic Assessments

Because the proposed measure is intended to supplement the 2022 CASE report on Nonresidential Grid Integration, much of the market impacts and economic assessments it contains is also directly applicable to this proposal. For brevity, that information is not repeated in this report. In addition to the information contained below, readers are encouraged to review the Grid Integration report for more information on market impacts of demand responsive control technologies [CASE, 2020].

3.2.1 Impact on Builders

No significant impacts expected.

3.2.2 Impact on Building Designers and Energy Consultants

No significant impacts expected.

3.2.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Department of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules will remain in place. Complying with the proposed code change is not anticipated to have any impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.

3.2.4 Impact on Building Owners and Occupants (including homeowners and potential first-time homeowners)

Impacts on building occupants are expected to be minimal. However, some level of occupant education will be required to inform occupants on the behavior of controlled loads during demand response events. Building operators, owners, and managers should inform occupants of pending demand response events to reduce issues. It is expected that critical MELS devices are not connected to controlled receptacles and will not be impacted by a demand response event. Two-thirds of all MELS in nonresidential buildings have been excluded from this analysis to account for such a practice.

3.2.5 Impact on Building Component Retailers (including manufacturers and distributors)

Building component retailers will see an increase in the sale of demand responsive control systems and components.

3.2.6 Impact on Building Inspectors

The impact on building inspectors is expected to be minimal. Additional responsibilities are expected to align well with current practice. For more information see Section 2.5 Compliance and Enforcement.

3.2.7 Impact on Statewide Employment

No significant impact on statewide employment is anticipated. The proposed measure will be easily incorporated into existing projects. Existing workers will complete the design, installation, testing and verification of the proposed control devices.

3.3 Economic Impacts

In progress. The statewide life cycle net present value over one three year code cycle is: pending.

3.3.1 Creation or Elimination of Jobs

See Section 3.2.7 Impact on Statewide Employment.

3.3.2 Creation or Elimination of Businesses within California

See section 3.2.7 Impact on Statewide Employment.

3.3.3 Competitive Advantages or Disadvantages for Businesses within California

No impact on the competitive advantage of California businesses is anticipated from this measure.

3.3.4 Increase or Decrease of Investments in the State of California

See the CASE Report on Nonresidential Grid Integration for an estimate of the impacts to investments in the State of California. Their analysis estimates a relatively small increase of $8.3 million in investments across all grid integration elements [CASE, 2020]. CEA does not believe that the proposed measure would lead to a significantly different level of investments made in the California economy by businesses or individuals.

3.3.5 Effects on Innovation in Products, Materials, or Processes

The proposed measure will have a significant impact on product innovation and design processes. By creating a need for grid-responsive building technology, businesses will develop new innovations to meet those needs, ultimately working towards meeting California's Zero Net Energy, Decarbonization, Energy Savings, and Environmental Goals. Demonstration that many different types of building systems, included miscellaneous loads, which are historically ignored, are capable of cost-effectively contributing to an integrated electricity grid is a necessary step toward achieving the State's policy goals.

3.3.6 Effects on the State General Fund, State Special Funds and Local Governments

CEA does not expect the proposed measure to have a significant, additional impact on California's general fund, state special funds, or local government funds.

3.3.6.1 Cost to the State

No new costs are anticipated to the State. Existing budgets should already contain sufficient funding to support code updates, outreach and education.

3.3.6.2 Cost to Local Governments

Existing compliance forms and processes can be modified to include checks for the proposed measure devices and functionality. CEA does not anticipate any significant new costs to local governments and building departments. The proposed updates can be included in ongoing education and training programs already available to code professionals. Additionally, the inclusion of an acceptance test for controlled receptacles, including controlled receptacles with demand response capabilities, may decrease the demand on building inspectors, freeing some time for addressing other parts of their government responsibilities, which would have a positive, although limited, overall effect.

3.3.6.3 Impacts on Specific Persons

No significant impacts on specific persons is expected.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

The CEA performed a literature review of published research studies that quantified the energy use of MELS in commercial spaces. The review focused on studies that included MELS energy estimates for spaces required to install controlled receptacles per Section 130.5(d) of the Energy Standards: offices, lobbies, conference rooms, kitchen areas in offices and copy rooms. The review resulted in a collection of seven studies spanning the years 2006 to 2017, which were consistent in methodology, peer-reviewed, and applicable to these commercial spaces. These seven studies contained a total of 10 different estimates of MELS energy use. The review identified three additional studies, which were removed from the sample, because they had values that fell outside two standard deviations of mean of the other eight, applied to residential buildings, or contained information pertaining to non-regulated commercial space types. The average annual MELS energy use utilized in this energy savings analysis, 2.30 kWh/sf/year, was based on values provided in these studies. This value is used to estimate the MELS load installed in applicable spaces within12 common nonresidential building types for the purposes of estimating energy use, costs and benefits. The study list is provided in Table 6.

Table 6. Studies on plug, process and miscellaneous electric loads

MELS Energy Use (kWh/sf/yr)	Reference	Author	Publication Year
2.97	California Commercial End-Use Survey	CEC	2006
2.00	Office Plug Load Field Monitoring Report	ECOS	2008
0.94	Commercial Office Plug Load Savings and Assessment	ECOVA	2011
1.30	Commercial Office Plug Load Savings and Assessment	ECOVA	2011
3.39	Variance and Optimization in Nonresidential Building Simulation Receptacle Loads (office)	Cadmus	2017
2.79	Variance and Optimization in Nonresidential Building Simulation Receptacle Loads (retail – office)	Cadmus	2017
1.78	Plug and Process Loads Capacity and Power Requirements Analysis (large office)	NREL	2014

1.07	Plug and Process Loads Capacity and Power Requirements Analysis (small office)	NREL	2014
2.97	Modeling Plug-In Equipment Load Patterns in Private Office Spaces	Gunay, et. al.	2016
3.78	US Department of Energy Commercial Reference Building Models of the National Building Stock	NREL	2011

4.2 Energy Savings Methodology

To assess the energy, demand, and energy cost impacts, CEA compared current design practices to design practices that would comply with the proposed requirements. There is an existing Title 24 standard that covers a majority of the building systems in question, so the existing conditions assume a building minimally complies with the 2019 Title 24 Standards, Section 110.12(c), 130.1(e) and 130.5(d). This analysis assumes that a building is required to install controlled receptacles per Section 130.5(d) and demand responsive lighting controls per Section 130.1(e) and 110.12(c).

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, the proposed code change demonstrates that when non-residential buildings are required to install demand responsive lighting systems and controlled receptacles, the addition of demand response capabilities for controlled receptacles is cost-effective over the life of the system.

Energy Commission provided guidance on the type of prototype buildings that were modeled to demonstrate energy savings and cost-effectiveness of the proposed measure. Nonresidential energy saving estimates are calculated using ASHRAE 90.1 prototypes for nonresidential buildings available in CBECC-Com. The CEA used the same prototype buildings included in the IOU CASE report on Nonresidential Grid Integration: Small Office, Medium Office, Large Office, Small Hotel, Quick Service Restaurant, Primary School, Secondary School, Warehouses (non-refrigerated), Strip Mall, Large Retail, Stand-Alone Retail and Mixed Use Retail Buildings.

To determine the percent of each building applicable to the proposed measure, CEA applied the 2016 Database for Energy Efficient Resources (DEER) space type percentages for areas required to install controlled receptacles to the total area of each of building type (DEER, 2015). This resource was used to provide the additional level of detail required and matches the methodology employed in the IOU CASE Report on Nonresidential Grid Integration. Table 7 presents the details of the prototype buildings used in the analysis.

Energy savings for the proposed measure, by building type, are based on the assumption that 1/3 of MELS within applicable building spaces are connected to controlled receptacles, and that during a demand response event, those devices are turned fully off for the event duration. To be conservative, the analyses assumes that all controlled receptacles are also controlled by zonal occupancy sensors and that during demand response events, a portion of these receptacles will already be fully off. This results in a discount rate equal to the expected occupancy rate of the impacted space. CEA applied the occupancy rates for various space types using the same occupancy rate values and methodology as described in the IOU CASE proposal on Nonresidential Grid Integration to arrive at the net (discounted) area, by building type, available for the proposed measure.

It is assumed that buildings enroll in an appropriate utility demand response program to realize savings and that all savings occur as a result of the building's participation in a demand response event called by their local utility. It is assumed that all such events occur during peak periods, which are called between 2 pm and 9 pm. Therefore, all demand savings are estimated to occur during peak periods. This analysis utilized the same methodology as the IOU CASE proposal on Nonresidential Grid Integration to determine the annual participation hours for applicable building areas with controlled receptacles. Under this methodology, it is assumed that an average utility demand response program includes 25 events per year that each last for 3.5 hours. To align with these events, the CEA assumed the events occurred during the top 88 most "expensive" TDV hours in the year.

Because the peak period of 2pm to 9pm crosses the traditional "close of business" time for many building types, it cannot be assumed that every building will be open and participating in all 25 demand response events. To account for variances in operating hours, CEA collected building equipment use schedules from the ASHRAE 90.1 prototypes. These schedules consist of a 3-part, 24-hour times series data set composed of demand factors (ranging from 0 to 1) for each hour of a typical weekday, typical weekend, and holiday. Each schedule is tailored to the building type and space. CEA applied these schedules to the 8760 hours of annual TDV values to determine the percent MELS load, by building type, that was ON (fully energized) for each hour of the year. Then, CEA sorted the values and took the top 88 values to represent the hours in the demand response event and the percent of load ON during that hour.

To determine the statewide area impacted by the proposed measure, CEA began with statewide values available for lighting demand response provided in the IOU CASE team proposal on Nonresidential Grid Integration. It then discounted these values by the percent area applicable to the proposed measure as shown below in Table 6. For existing buildings, very few are required to install controlled receptacles as part of the retrofit. Only when the entire electrical system is replaced are they required. To account for this fact, CEA discounted the statewide existing building stock by 90 additional percent so that just 10 percent of applicable retrofits are assumed to be impacted by the proposed measure. The total statewide area applicable to the proposed measure, by building type, after discounts for occupancy controls, limited retrofits addressing controlled receptacles and other items discussed, is provided in Table 7. CEA estimates that there will be approximately 57 million sf of building stock impacted by the proposed measure in 2023, the first year of the standards, assuming full compliance.

Table 7: Prototype Buildings used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype ID	Total Area per Building (sf)	Percent Area Applicable to Proposed Measure*	Net Area Applicable to Proposed Measure (sf)	Net Statewide Applicable Area (2023 million sf)
Small Office	5,500	54%	2,955	2.39
Medium Office	53,600	54%	28,794	19.60
Large Office	498,600	68%	339,048	24.81
Strip Mall	22,500	9%	2,133	0.16
Stand-alone Retail	24,695	8%	1,897	0.27
Large Retail	240,000	8%	18,436	3.65
Mixed Use Retail	9,375	9%	804	0.30
Primary School	73,960	16%	11,891	2.59
Secondary School	210,900	16%	33,907	1.73
Warehouse	49,495	2%	1,109**	1.15
Quick Service Restaurant	2,500	6%	144**	0.16
Small Hotel	43,200	5%	2,203	0.28

*After occupancy savings, 90% discount for limited retrofits, and other reductions (see IOU CASE Report on Grid Integration)

** Modeled as an area of 1900 sf.

Energy savings, energy cost savings and peak demand savings were calculated on an hourly basis using a Time Dependent Valuation (TDV) methodology. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. The impacts of the proposed measure are generally not climate specific, however some variation does exist due to variation in the TDV factors among climate zones. However, MELS wattage and hours of operation have significantly more impact on energy savings than climate. Interaction effects with HVAC due to equipment/MELS heat gain are small and are neglected in this analysis. As a result, the cost-effectiveness of this measure is deemed to be independent of climate zone. Thus, statewide average TDV factors were used in the energy and cost analysis.

4.3 Per Unit Energy Impacts and Energy Savings Results

Energy savings, peak demand savings and per unit energy and demand impacts of the proposed measure are presented in Table 8. Per unit savings for the first year are expected to range from 0.014 to 0.015 kilowatt-hours per square foot per year (kWh/sf/yr). Peak demand savings are expected to range from 0.000515 to 0.000615 (kW/sf). No per-unit therm savings are expected from this measure. It is estimated that the first year TDV energy savings range from 0.132 to 0.211 TDV-kBTU/yr/sf.

For buildings that must comply with both Section 110.12 – Demand Responsive Lighting Controls and Section 130.5 – Controlled Receptacles, the energy savings are the same for both new construction and alterations.

Table 8: First Year Energy Impacts per Square Foot (Nonresidential Building Stock)

Prototype Building	Electricity Savings (kWh/sf/yr)	Peak Electricity Demand Savings (kW/sf)	TDV Energy Savings (TDV-kBTU/sf/yr)
Small Office	0.015	0.000615	0.132
Medium Office	0.015	0.000615	0.132
Large Office	0.015	0.000615	0.132
Strip Mall	0.014	0.000545	0.211
Stand-alone Retail	0.014	0.000545	0.211
Large Retail	0.014	0.000545	0.211
Mixed Use Retail	0.014	0.000545	0.211
Primary School	0.015	0.000591	0.135
Secondary School	0.015	0.000591	0.135
Warehouse	0.015	0.000552	0.135
Quick Service Restaurant	0.014	0.000545	0.211
Small Hotel	0.014	0.000515	0.171

5. Life Cycle Cost and Cost-Effectiveness

5.1 Energy Cost Savings Methodology

TDV energy is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2023 present valued dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV-kBTUs". Peak demand savings are presented in peak power reductions (kW/sf). Energy Commission derived the 2023 TDV values that were used in the analyses for this report (Energy Commission 2019).

5.2 Energy Cost Savings Results

The per unit TDV energy cost savings over the 15-year period of analysis are presented in Table 9. These are presented as the discounted present value of the energy cost savings over the analysis period. The proposed measure results in cost savings in every climate zone.

Table 9: TDV Energy Cost Savings Over 15 Year Period of Analysis - Per Square Foot (Nonresidential Building Stock)

Building Prototype	15 Year TDV Electricity Cost Savings (2023 PV $)	15 Year TDV Natural Gas Cost Savings (2023 PV $)	Total 15 Year TDV Energy Cost Savings (2023 PV $)
Small Office	$0.18	None	$0.18
Medium Office	$0.18	None	$0.18
Large Office	$0.18	None	$0.18
Strip Mall	$0.28	None	$0.28
Stand-alone Retail	$0.28	None	$0.28
Large Retail	$0.28	None	$0.28
Mixed Use Retail	$0.28	None	$0.28
Primary School	$0.18	None	$0.18
Secondary School	$0.18	None	$0.18
Warehouse	$0.18	None	$0.18
Quick Service Restaurant	$0.28	None	$0.28
Small Hotel	$0.23	None	$0.23

5.3 Incremental First Cost

The CEA estimated the current incremental construction costs and post-adoption incremental construction costs. The current incremental construction cost represents the incremental cost of the measure if a building meeting the proposed standard were built today. The post-adoption incremental construction cost represents the anticipated cost assuming full market penetration of the measure as a result of the new Standards, resulting in possible reduction in unit costs as manufacturing practices improve over time and with increased production volume of qualifying products the year the Standard becomes effective. Per Energy Commission's guidance, design costs are not included in the incremental first cost.

Lighting demand response is commonly achieved by installing a networked lighting control system (NLCS) or building management system (BMS), equipped with a native virtual end node (VEN) that connects with a utility virtual top node (VTN) to transmit demand response signals between the utility and the building. In the case of NLCS, each lighting circuit, lighting zone or luminaire is paired with load controller that processes control instructions from the network hub to control the lighting under its command. To enable demand response for controlled receptacles, each controlled circuit is paired with a similar load controller or control module, which is mounted in a junction box using standard electrical wiring practices. During commissioning, each load controller is assigned to a demand response zone that dictates the specific actions that will occur for all devices in the zone during a demand response event.

Because the measure is proposed only for projects that already require lighting demand response and controlled receptacles, the incremental cost to enable demand responsive controlled receptacles consists of only the load controller; miscellaneous electrical supplies such as junction boxes, wire, and wire nuts; and the labor to install the device and assign it to a control zone. CEA assumes the building is wired such that controlled receptacles reside on their own circuits, apart from non-controlled receptacles, as is standard practice (NEMA, 2016)

For BMS, the process is very similar, and circuits containing controlled receptacles are assigned to demand response control zones much like lighting or other loads. The only incremental cost pertains to assigning circuits to control zones in the BMS.

It should be noted that, while possible, it is not common for new construction projects and major renovations, which form the entire basis of projects impacted by this measure, to utilize a piecemeal approach with non-native VEN. However, when these devices are utilized, they most often come with 0-10V relays that can be used to achieve demand response with connected loads. The relay switches the loads from ON to OFF during a demand response event. In this scenario, only some minor additional wiring is required to connect the circuits with controlled receptacles to the non-native VEN's 0-10V relay output. They may also communicate with a number of different wireless communication protocols common in today's buildings and wireless communication and connectivity is possible for suitably equipped controlled receptacles. In this scenario, only the time to link the receptacle with the VEN and assign it to a control zone using the VEN's software interface is required.

For this measure analysis, CEA utilized costs associated with enabling demand responsive controlled receptacles with a networked lighting control system. This scenario represents the most expensive configuration deployed in today's buildings.

In order to determine the incremental cost of this solution, the number of circuits serving plug loads per square foot is needed. Once this value is known, we can assume 50 percent of those are controlled. This is achieved through use of two branch circuits and; split wiring of all dual receptacles so that each dual-receptacle has one receptacle on a controlled circuit and one on an uncontrolled circuit or alternating wiring of each dual-receptacle so that every other dual-receptacle is on the same circuit [NEMA, 2016].

Common design practice assigns 1 VA per square foot for miscellaneous receptacle loads in commercial buildings. Assuming use of a 2o-amp circuit at 120 volts and derated by 20 percent per the National Electrical Code, each can serve approximately 1900 square feet of building space. Each 15-amp circuit can serve approximately 1400 square feet of space. Half of these circuits must be controlled.

- 20 amp circuit: 1(VA/sf)*1900 sf = 1900 VA → 20A * 120V*0.80 = 1920 VA
- 15 amp circuit: 1(VA/sf)*1400 sf = 1400VA → 15A *120V*0.80 = 1440 VA

CEA surveyed online retails and distributors to documents costs for load controllers and other materials required to enable demand responsive controlled receptacles connected to networked lighting control systems. The survey included both wired and wireless solutions. The average bill of materials, per circuit including installation, commissioning, sales tax, and 15 percent profit/market is $284.13. A list of configurations, products and pricing is shown Table 10.

5.4 Lifetime Incremental Maintenance Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the period of analysis. The present value of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2022 TDV. The present value of maintenance costs that occurs in the nth year is calculated as follows (where d is the discount rate of 3 percent):

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left\lfloor \frac{1}{1+\text{d}} \right\rfloor^{\text{n}}$$

The devices required to enable demand responsive controlled receptacles are expected to last over the entire life of the measure, 15 years. No maintenance is required once the unit is added to a demand response zone as part of initial commissioning. Information was obtained through a review of manufacturer's literature and interviews with major building control manufacturers conducted in April – May 2020. Energy savings are expected to persist for as long as the building owner remains enrolled in a utility demand response program.

Table 10. Bill of Materials to enable a 20-amp Circuit for Demand Response as Part of Networked Control System

Manufacturer A	Plug Load Controller		$117.50
(wired)	CAT5 cable (100')		$ 20.00
		Subtotal	$137.50
		Tax	$ 10.31
	Installation: 0.5 hours/$116.02		$ 58.01
	Commissioning: 0.25 hours/$120/hr		$ 30.00
	Markup @15%		$ 30.87
		Total	**$266.70**
Manufacturer B			
(wired)	Sector Relay		$110.00
	Sales Tax		$ 8.25
	Installation: 0.5 hours/$116.02		$ 58.01
	Commissioning: 0.25 hours/$120/hr		$ 30.00
	Markup @ 15%		$ 26.44
		Total	**$232.70**
Manufacturer B			
(wireless)	Controlled receptacle		$140.00
	20 amp receiver		$100.00
	Sales Tax		$ 10.50
	Commissioning: 0.25 hours/$120/hr		$ 30.00
	Installation: 0.5 hours/$116.02		$ 58.01
	Markup @ 15%		$ 50.78
		Total	**$389.29**
Manufacturer C	Plug load control power pack/20 amp		$122.25
(wired)	Sales Tax		$ 9.17
	Installation: 0.5 hours/$116.02		$ 58.01
	Commissioning: 0.25 hours/$120/hr		$ 30.00
	Markup @ 15%		$ 28.41
		Total	**$247.84**
		Average	**$284.13**

5.5 Lifecycle Cost-Effectiveness

This measure proposes a mandatory requirement. As such, a lifecycle cost analysis is required to demonstrate that the measure is cost-effective over the 15-year period of analysis.

Energy Commission's procedures for calculating lifecycle cost-effectiveness are documented in its LCC Methodology. The CEA followed these guidelines when developing the cost-effectiveness analysis for this measure. Energy Commission's guidance dictated which costs were included in the analysis. Incremental first cost and incremental maintenance costs over the 15-year period of analysis were included. The TDV energy cost savings from electricity were also considered. Design costs were not included nor was the incremental cost of code compliance verification.

According to Energy Commission's definitions, a measure is cost-effective if the Benefit-to-Cost (B/C) Ratio is greater than 1.0. The B/C Ratio is calculated by dividing the total present lifecycle cost benefits by the present value of the total incremental costs. Results per unit lifecycle Cost-effectiveness Analyses are presented in Table 11.

The proposed measure was found to be cost-effective in every climate zone for each building type modeled, with the exception of quick service restaurants and warehouses, which had very small areas required to have controlled receptacles. As such, the MELS load in these spaces, as modeled, was not large enough to deliver energy savings over the 15-year period of analysis. However, additional analysis shows that the proposed measure installed in these buildings is cost-effective when the building is constructed with 1900 sf or more of dedicated office, lobby, or other space requiring controlled receptacles per Section 130.5 of the Energy Standards. This is the approximate area served by a fully loaded 20-amp circuit. Given the 4000 watt threshold and other changes proposed by the IOU CASE team for the 2022 Standards related to lighting demand response, areas under 1900 sf will be exempt from demand responsive lighting controls and thus, exempt by default from the proposed measure here.

Table 11: Life Cycle Cost-effectiveness Summary Per Square Foot

Prototype Building	Benefits TDV Energy Cost Savings + Other PV Savings[1] (2023 PV $)	Costs Total Incremental Present Valued (PV) Costs[2] (2023 PV $)	Benefit-to-Cost Ratio
Small Office	$0.18	$0.10	1.8
Medium Office	$0.18	$0.08	2.3
Large Office	$0.18	$0.07	2.6
Strip Mall	$0.28	$0.13	2.2
Stand-alone Retail	$0.28	$0.15	1.9
Large Retail	$0.28	$0.08	3.5
Mixed Use Retail	$0.28	$0.09	3.1
Primary School	$0.18	$0.07	2.6
Secondary School	$0.18	$0.08	2.3
Warehouse	$0.18	$0.15	1.2
Quick Service Restaurant	$0.28	$0.15	1.9
Small Hotel	$0.23	$0.13	1.8

1. **TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis. Other savings are discounted at a real 3% rate. Includes incremental first cost savings if proposed first cost is less than current first cost. Includes present value maintenance cost savings if PV of proposed maintenance costs is less than the PV of current maintenance costs.
2. **Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement and maintenance costs over the period of analysis. Present value cost = Current cost x (1/(1.03)^n. Costs are discounted by 3% real rate. Includes incremental first cost if proposed first cost is greater than current first cost. Includes present value of maintenance incremental cost if PV of proposed maintenance costs is greater than the PV of current maintenance costs. If incremental maintenance cost is negative it is treated as a positive benefit. If there are no Total Incremental Present Valued Costs, the Benefit/Cost Ratio is Infinite.

6. First Year Statewide Impacts

6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

The CEA calculated the first year statewide savings by multiplying the per unit savings, which are presented in Section 4.3 by the statewide new construction forecast for 2023, which is presented in more detail in Appendix A: Statewide Savings Methodology. The first year energy impacts represent the first-year annual savings from all buildings that were completed in 2023. The lifecycle energy cost savings represents the energy cost savings over the entire 15-year period of analysis. Results are presented in Table 12.

Given data regarding the new construction forecast for 2023, the CEA estimates that the proposed code change will reduce annual statewide electricity use by 0.85 GWh with an associated demand reduction of 34.6 MW. The energy savings for buildings constructed in 2023 are associated with a present valued energy cost savings of approximately PV$ 10.74 million in (discounted) energy costs over the 15-year period of analysis. Nominal cost savings over the 15-year analysis period is estimated to be $15.64 million[1].

[1] Total Lifecycle Present Value Energy Cost Savings * 0.083 * 17.56 per methodology described in 2022 TDV and Source Energy Metric Data Sources and Inputs (E3, 2020)

Table 12: Statewide Energy and Energy Cost Impacts

Building Type	Statewide Construction in 2023 (nonres: million sf)	First Year[1] Electricity Savings (GWh)	First Year[1] Peak Electrical Demand Reduction (MW)	First Year[1] Source Energy Savings (million-kBtu/sf)	Lifecycle[2] Present Valued Energy Cost Savings (PV$ million)
Small Office	2.39	0.04	1.5	0.32	$ 0.431
Medium Office	19.60	0.29	12.1	2.59	$ 3.527
Large Office	24.81	0.37	15.3	3.27	$ 4.465
Strip Mall	0.16	0.00	0.1	0.03	$ 0.046
Stand-alone Retail	0.27	0.00	0.1	0.06	$ 0.075
Large Retail	3.65	0.05	2.0	0.77	$ 1.022
Mixed Use Retail	0.30	0.00	0.2	0.06	$ 0.083
Primary School	2.59	0.04	1.5	0.35	$ 0.467
Secondary School	1.73	0.03	1.0	0.23	$ 0.311
Warehouse	1.15	0.02	0.6	0.16	$ 0.207
Quick Service Restaurant	0.16	0.00	0.1	0.03	$ 0.044
Small Hotel	0.28	0.00	0.1	0.05	$ 0.064
TOTAL	57.08	0.85	34.6	7.9207	$ 10.743

1. First year savings from all buildings completed statewide in 2023.
2. Energy cost savings from all buildings completed statewide in 2023 accrued during 15-year period of analysis.

6.2 Statewide Greenhouse Gas Emissions Reductions

The CEA calculated avoided greenhouse gas (GHG) emissions assuming the emissions factors specified in the USEPA Emissions & Generation Resource Integrated Database (eGRID) for the WECC California (CAMX) subregion. The electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the state meets the Renewable Portfolio Standard (RPS) goal of 33 percent renewable electricity generation by 2020. [2]. The eGRID database attributes 498.7 lbs-CO_{2e} per megawatt-hour to the California region [EPA, 2020].

Table 13 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year greenhouse gas emissions of 4,571 metric tons of carbon dioxide equivalents ($MTCO_2e$) would be avoided as compared to a business-as-usual scenario.

Table 13: First Year[1] Statewide Greenhouse Gas Emissions Impacts

Electricity Savings (GWH/yr)	Reduced GHG Emissions from Electricity Savings (MT CO_2e)	Natural Gas Savings (Million Therm/yr)	Reduced GHG Emissions form Natural Gas Savings (MT CO_2e)	Total Reduced CO2e Emissions[2] (MT CO_2e)
0.85	192.6	0	0	**192.6**

1. First year savings from all buildings completed statewide in 2023.
2. Assumes the following emission factors: 498.7 lbs-CO2e/GWh.

6.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.4 Statewide Material Impacts

The proposed code change will not result in material impacts.

6.5 Other Non-Energy Impacts

The IOU CASE report on Nonresidential Grid Integration details several types of non-energy benefits associated with demand response equipment including decreased operational and maintenance costs, and improved space utilization. Savings from non-energy benefits can be an order of magnitude or

---

[2] When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The incremental emissions were calculated by dividing the difference between California emissions in the CARB high and low generation forecasts by the difference between total electricity generated in those two scenarios.

higher than the energy savings alone [CASE, 2020]. Currently, the TDV methodology does not account for these benefits and they are not included elsewhere in this proposal. The CEA recommends these benefits be considered for future cost-effectiveness metrics and methodologies in order to capture the true value of demand responsive technologies. For more information on these benefits, readers should review IOU CASE team proposal on Nonresidential Grid Integration, a 2019 California Energy Commission study entitled *The Value Proposition for Cost-Effective, Demand Response-Enabling, Nonresidential Lighting System Retrofits in California Buildings,* and other resources cited in both those documents.

7. PROPOSED REVISIONS TO CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2019 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

7.1 Standards

SECTION 110.12 – MANDATORY REQUIREMENTS FOR DEMAND MANGEMENT

...

(e) Demand Responsive Controlled Receptacles. Controlled receptacles in buildings shall be capable of automatically turning off all loads connected to the receptacle in response to a demand response signal.

Exception 1 to 110.12(e): Buildings not required to have demand responsive lighting controls.

Exception 2 to 110.12(e): Spaces where a health or life safety statute, ordinance, or regulation does not permit the receptacles to be automatically controlled.

SECTION 130.4 – LIGHTING CONTROL ACCEPTANCE AND INSTALLATION CERTIFICATE REQUIREMENTS

...

(a) Lighting Control Acceptance Requirements.

...

8. Certifies that demand responsive controls required to control controlled receptacles comply with Section 130.5(d) and Nonresidential Appendix NA7.6.3.

SECTION 130.5 – ELECTRICAL POWER DISTRIBUTION SYSTEMS

(e) Demand responsive controls and equipment. See Section 110.12 for requirements for demand responsive controls and equipment~~.~~ including demand responsive controls for controlled receptacles.

Section 141.2(P) – Electrical Power Distribution Systems

iv. **Circuit Controls for 120-Volt Receptacles and Controlled Receptacles.** For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 130.5(d) <u>and 130.5(e).</u>

7.2 Reference Appendices

Reference appendix 7.6.3 will require additions to describe the acceptance test for controlled receptacles equipped with demand responsive controls.

Pending.

7.3 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

7.4 Compliance Manuals

Chapter 8 of the Nonresidential Compliance Manual will need to be revised. Additions are recommended to Chapter 5 – Indoor Lighting to reference the new requirements. Chapter 13 – Acceptance testing will also require changes to the demand responsive lighting controls content.

7.5 Compliance Forms

Forms NRCC-ELC-E, NRCI-ELC-01-E, and NRCA-LTI-A will require modifications to account for the new requirements. No new forms are required.

8. References

[ASHRAE] Association of Heating, Refrigeration and Air Conditioning Engineers. 2019. "Energy Standard for Buildings except Low-Rise Residential Buildings (I-P Edition)."

[CA DWR] California Department of Water Resources. 2016. "California Counties by Hydrologic Regions". http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf. Accessed April 3, 2016.

[CASE] California Statewide Codes & Standards Enhancement Program. 2020. "Nonresidential Grid Integration." https://title24stakeholders.com/wp-content/uploads/2019/06/NR-Grid-Integration_Draft-CASE-Report_Statewide-CASE-Team.pdf. Accessed June 15, 2020.

[CPUC] California Public Utilities Commission. 2015a. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

[CPUC] California Public Utilities Commission. 2015b. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350

[CARB] California Air Resources Board. 2010. "Proposed Regulation for a California Renewable Electricity Standard Staff Report: Initial Statement of Reasons Appendix D." http://www.arb.ca.gov/regact/2010/res2010/res10d.pdf. Accessed November 12, 2013.

[Energy Commission] California Energy Commission. 2019 {placeholder for Energy Commission 2019 Lifecycle Cost Methodology Report}.

[NEMA] National Electrical Manufacturers Association. 2016. "Automatic Receptacle Control to Meet ASHRAE 90.1-2010 and California Title 24". http://accuratetechinc.com/wp-content/uploads/2016/11/NEMAWDARCP1-2016WATERMARKED.pdf. Accessed June 22, 2020.

U.S. Census Bureau. 2014. Population Division. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

[U.S. DOE] United States Department of Energy. 2016. "Miscellaneous Electric Loads: What Are They and Why Should you Care."

https://www.energy.gov/eere/buildings/articles/miscellaneous-electric-loads-what-are-they-and-why-should-you-care. Accessed June 24, 2020.

[U.S. EPA] United States Environmental Protection Agency. 2011. "Emission Factors for Greenhouse Gas Inventories." http://www.epa.gov/climateleadership/documents/emission-factors.pdf. Accessed December 2, 2013.

[U.S. EPA] United States Environmental Protection Agency. 2020. "eGRID 2018 Summary Tables." https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf. Accessed June 23, 2020.

APPENDICES

Appendix A: Statewide Savings Methodology

Nonresidential Buildings

The Energy Commission Demand Analysis Office provided California Energy Alliance with the residential and nonresidential new construction forecast for 2023, broken out by building type and forecast climate zones (FCZ). Table 15 provides a mapping of the various space types used in the forecast to the nonresidential prototypes. The projected nonresidential new construction forecast by building type is presented in Table 17. Table 16 presents the assumed percent of new construction that would be impacted by the proposed code change.

Table 14: Description of Space Types used in the Nonresidential New Construction Forecast

OFF-SMALL	Offices less than 30,000 ft^2
OFF-LRG	Offices larger than 30,000 ft^2
REST	Any facility that serves food
RETAIL	Retail stores and shopping centers
FOOD	Any service facility that sells food and or liquor
NWHSE	Nonrefrigerated warehouses
RWHSE	Refrigerated Warehouses
SCHOOL	Schools K-12, not including colleges
COLLEGE	Colleges, universities, community colleges
HOSP	Hospitals and other health-related facilities
HOTEL	Hotels and motels
MISC	All other space types that do not fit another category

Table 15: Mapping Factors for Construction Building Types to Nonresidential Prototypes

Building Type *Building sub-type*	**Composition of Building Type by Sub-types**
Small Office	100%
Restaurant (Quick Service)	100%
Retail	
Stand-Alone Retail	10%
Large Retail	75%
Strip Mall	5%

Mixed-Use Retail	10%
Non-Refrigerated Warehouse	100%
Schools	
Small School	60%
Large School	40%
Hotel/Motel (Small Hotel)	100%
Large Offices	
Medium Office	50%
Large Office	50%

Table 16: Net Percent of New Construction Impacted by the Proposed Measure

Type of Nonresidential Space	% Available for Measure	Total Building Stock Impacted
Office Small	3.3%	8.622868847
Office Medium	10%	15.16477391
Office Large	10%	15.16477391
Strip Mall	5.5%	1.304830791
Stand-Alone Retail	5.5%	2.609661581
Retail Large*	10%	19.57246186
Retail Mixed Use	5.5%	2.609661581
Primary School	9.5%	6.124591908
Secondary School	9.5%	4.083061272
Warehouse (Non-Refrigerated)	8.6%	25.39278548
Quick Service Restaurant	3.9%	4.426496596
Small Hotel	2.5%	9.104290241

Table 17: Estimated New Nonresidential Construction in 2023 by Climate Zone and Building Type (Million Square Feet)

Source: Energy Commission Demand Analysis Office

Climate Zone	Small Office	Large Office	Restaurant	Retail	Grocery Store	Non-Refridgerated Warehouse	Refridgerated Warehouse	Schools	Colleges	Hospitals	Hotel/Motels	Miscellaneous
CZ 1	0.035175679	0.114797092	0.015379671	0.105887256	0.028460539	0.077259841	0.006231054	0.04870007	0.026546969	0.036211927	0.041751313	0.141552663
CZ 2	0.209022613	0.681621566	0.091362485	0.628999777	0.169099564	0.459149381	0.037054174	0.289356793	0.157689232	0.21513154	0.247947981	0.840814991
CZ 3	0.744038483	3.84212879	0.375165837	2.874726862	0.707800043	2.381855334	0.188952222	1.18067699	0.686909604	0.926748956	1.137828895	3.902283704
CZ 4	0.371969234	2.016253088	0.191394041	1.473399101	0.35899845	1.223486071	0.095815086	0.599111674	0.352071955	0.472184558	0.58754426	2.005538066
CZ 5	0.081298635	0.352725792	0.039001705	0.298227991	0.075593021	0.227281805	0.01927542	0.123822888	0.070626718	0.098480811	0.114362194	0.397779333
CZ 6	0.558138383	2.756426756	0.3800881	2.101335062	0.530878465	1.879997722	0.066772083	0.664616851	0.372107159	0.493892702	0.696703576	2.274822727
CZ 7	0.772988876	1.550141896	0.24806473	1.482067296	0.445073286	1.1082226	0.012656057	0.712507276	0.327665594	0.540321717	0.749614881	1.71981507
CZ 8	0.732204995	4.126620956	0.548342207	3.016191618	0.749164113	2.70201865	0.096477602	0.912297864	0.525479391	0.7235149	0.965376588	3.29775223
CZ 9	1.177502719	7.6788254	0.922433768	4.715759812	1.152329445	4.322036636	0.14203058	1.229060799	1.002011619	1.316951125	1.488419716	5.294852785
CZ 10	0.985711895	1.508027947	0.650791893	2.823354783	0.779888816	3.441195004	0.085550445	1.24915386	0.494491624	0.701735466	0.815201147	3.534685651
CZ 11	0.269042391	0.322487964	0.087931169	0.582022642	0.192766995	0.636824843	0.072258626	0.332905257	0.138454675	0.220068516	0.164340971	0.731782204
CZ 12	1.409103395	3.215716027	0.412343265	3.170179704	0.824079044	3.186690674	0.24290583	1.399892443	0.640806471	1.035311599	0.971757296	3.756807791
CZ 13	0.574557079	0.494845784	0.190763258	1.218458015	0.409627114	1.087092988	0.187033625	0.7254288	0.27364938	0.457269252	0.307314035	1.518142169
CZ 14	0.192726772	0.519041463	0.143149606	0.668169197	0.176125064	0.739574393	0.029889473	0.258330693	0.107431586	0.152382005	0.17852401	0.804140631
CZ 15	0.188980329	0.157913275	0.071415598	0.384238626	0.129441391	0.540421347	0.017321534	0.180968942	0.047201487	0.087358084	0.134416492	0.466390385
CZ 16	0.078110511	0.133203774	0.041232214	0.211890727	0.061880138	0.224714437	0.019073779	0.099407927	0.03977503	0.059863326	0.054606776	0.262363905
Total	8.380571988	29.47077757	4.408859548	25.75490847	6.79120549	24.23782173	1.319297591	10.00623913	5.262918496	7.537426482	8.655710133	30.94952431

Appendix C: Environmental Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

Avoided GHG emissions are calculated assuming the emissions factors specified in the USEPA Emissions & Generation Resource Integrated Database (eGRID) for the WECC California (CAMX) subregion[3]. This ensures consistency between state and federal estimations of potential environmental impacts.

To be conservative, the authors calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in USEPA's Compilation of Air Pollutant Emissions Factors (AP-42)[4].

Greenhouse Gas Emissions Monetization Methodology

The 2022 TDV cost values used in the LCC Methodology includes the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs) and the Cost-effectiveness Analysis presented in Section 5 of this report does include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the authors disaggregated the value of avoided GHG emissions from the other economic impacts. The authors used the same monetary values that are used in the TDV factors – $XX/MTCO$_2$e. Placeholder

Water Use and Water Quality Impacts Methodology

There are no expected impacts on water quality or water use.

[3] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[4] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors